-64-400

COMPUTER CONFIGURATION ANALYSIS
OF THE
AIR FORCE WESTERN TEST RANGE, VANDENBERG AIR FORCE BASE, CALIFORNIA

TECHNICAL DOCUMENTARY REPORT NO. ESD-TDR-64-400

JUNE 1964

DEPUTY FOR ENGINEERING AND TECHNOLOGY
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

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FOREWORD

The National Range Division of the Air Force Systems Command, at the request of the Air Force Western Test Range, Point Arguello, Vandenberg Air Force Base, convened a study team on 19 March 1964. The purpose was to conduct a study of the Western Test Range (WTR) Computer Configuration. The operational control will become the responsibility of the Air Force on 1 July 1965. The Electronic Systems Division, Deputy for Engineering and Technology was requested to form a team to conduct the study and publish a report. The entire AFSC study team membership is:

STUDY TEAM MEMBERS

NRD	Captain W. J. Baird, Jr. (NRSP)	Project Officer, NRD
ESD	Maj C. M. Schultz (ESRIS)	ESD Team Leader
	Maj R. A. Meier (ESRCP)	Computer System Engineer
	Mr. N. S. Zimbel (MITRE)	Computer Tech Advisor
AFSTC	Lt. Col D. H. Coleman (STOD)	Chairman for WTR
	CWO V. L. Cartwright (STOD)	
AFMTC	Mr. S. A. DeMars (MTDR)	Computer Systems Engineer
	Capt J. F. Finkle (MTOE)	Data Reduction Specialist
NBS	Mr. D. Friedman (Div 12)	Consultant (currently working on an ESD computer study involving all ranges)

The Study Team made a visit to the Pacific Missile Range Headquarters, Point Mugu NAS, California. The Department of Range Operations people briefed the study team on the existing facilities and their ability to handle the presently assigned task of real time and post flight data analysis. A discussion was held on the proposed Real Time Data Handling System (RTDHS), its parts, and the assumed capability to cope with the data handling tasks.

A computer workload summary was prepared by the AFMTC people. With this, and the PMR information, sections 2, 3, 4, & 6 were written by the ESD representatives. The content of these sections was approved at a joint team meeting on 29 April 1964. All the material in related sections was then assembled so that it would comprise a completed report.

In reading this report, it should be kept in mind that the goal is the best practical solution to the problem, considering the short study time allowed and the necessity of assessing a Navy oriented data handling program under the Air Force concept of range operations.

ABSTRACT

This report is an evaluation of the present Computer Configuration that processes the pre-flight, real-time and post-flight data of the Pacific Missile Range. The evaluation assesses the present capability as to its adequacy at the time the Air Force assumes full responsibility for the Western Test Range.

It is determined that the present system is not sufficient to handle the needs of the range for the time period 1965-1969. The proposed system will cover the workload imposed by validated requirements for the time period. The proposed system will not be sufficient to handle the workload if proposed additional requirements are validated during the time period. The recommended actions are:

1. To discontinue the installation of the Navy contracted AN/USQ-20B computer systems, leaving such in the Navy inventory for use as the Navy specifies.

2. To up-grade the present IBM 7090 installation to an IBM 7094 plus four data channels and appropriate peripheral equipment.

3. To reanalyze the AFWTR computer needs in late FY-65 or early FY-66 to determine if any new requirements are imposed which cannot be satisfied by the recommended IBM 7094 system.

PUBLICATION REVIEW AND APPROVAL

This Report has been reviewed and is approved.

for GUSTAV E. LUNDQUIST
Colonel, USAF
Deputy for Engineering &
Technology

for ROY D. RAGSDALE
Colonel, USAF
Director, Aerospace
Instrumentation

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KEY WORD LIST

1. Computer
2. Data Processing
3. Pre-flight Data
4. Real Time Control
5. Post-flight Reduction

GLOSSARY

1.	AFETR	Air Force Eastern Test Range
2.	COTAR	Correlation Tracking and Ranging
3.	GERSIS	General Electric Range Safety Instrumentation System
4.	GERTS	General Electric Radio Tracking System
5.	NMFPA	Naval Missile Facility, Point Arguello
6.	PARSIP	Point Arguello Range Safety Impact Predictor Program
7.	PMR	Pacific Missile Range
8.	RATAC	Radar Analog Target Acquisition Data
9.	RTDHS	Real Time Data Handling System
10.	SPS	Samples per second
11.	TWRT	Trajectory Writing Routing Tape

1. STATEMENT OF THE PROBLEM

1.1 Range operations responsibilities for all missile launches from the Point Arguello/Vandenberg AFB complex will be transferred from the Navy to the Air Force (AFWTR) on 1 July 1965. A completely integrated and responsive data acquisition and processing system of telemetry, tracking and control devices, communications networks, and computers must be in place, operational and under AFWTR control prior to 1 July 1965.

1.2 Although significant problems exist in the telemetry, tracking, and communications areas, this study is limited to data processing systems only.

1.3 Normal lead time for the prescribed approval-acquisition-installation cycle for data processing systems is twelve to eighteen months. For this reason, AFSC and USAF approval of the recommendations in this study must be obtained at the earlist possible date (not later than 1 July 1964) to permit AFWTR to perform its mission as of 1 July 1965.

1.4 The official PMR/AFWTR Range Transfer Agreement lists:

1.4.1 The transfer of one Navy-owned UNIVAC USQ-20B computer system to AFWTR. However, subsequent PMR/AFWTR agreement has been reached to keep the USQ-20B computer system in the Navy inventory and issue it to AFWTR on hand receipt (if the USQ-20B computer is retained by AFWTR after 1 July 1965).

1.4.2 Any data processing workload in excess of AFWTR capabilities is to be levied on the 7094/1401 at the Test Data Division of PMR. This excess must be considered for processing within their workload capabilities. The Test Data Division 7094/1401 presently handles preflight preparation and post flight data reduction for Point Mugu (Sea Test Range) and Point Arguello (to be WTR) tests. This workload is steadily increasing and has already saturated the capabilities of this equipment. Approximately 200-250 computer hours per month are obtained from the Navy Astronautics Laboratory 7094 (located at Point Mugu, but not associated with the PMR). This equipment saturation at the present time suggests that the Point Mugu facilities will have little or no available processing time for the support of the WTR.

1.5 The entire AFWTR data reduction workload, as well as AFWTR range real-time computer applications, will be an AFWTR responsibility.

1.6 The purpose of this study, then, is to determine the minimum computer requirements to support the selected Pacific Missile Range (USN) functions and responsibilities that will be transferred to the Air Force Western Test Range, Vandenberg Air Force Base on 1 July 1965 and during the subsequent five year period

2. EXISTING DATA PROCESSING SYSTEM EQUIPMENT

2.1 The Point Arguello/Vandenberg Range Operations has now in place, as shown by Figure 1, the following major equipments to handle the Pre-Flight, Real-Time and limited Post-Flight Data Processing.

One (1) IBM 7090 processor with 32,000 word storage.

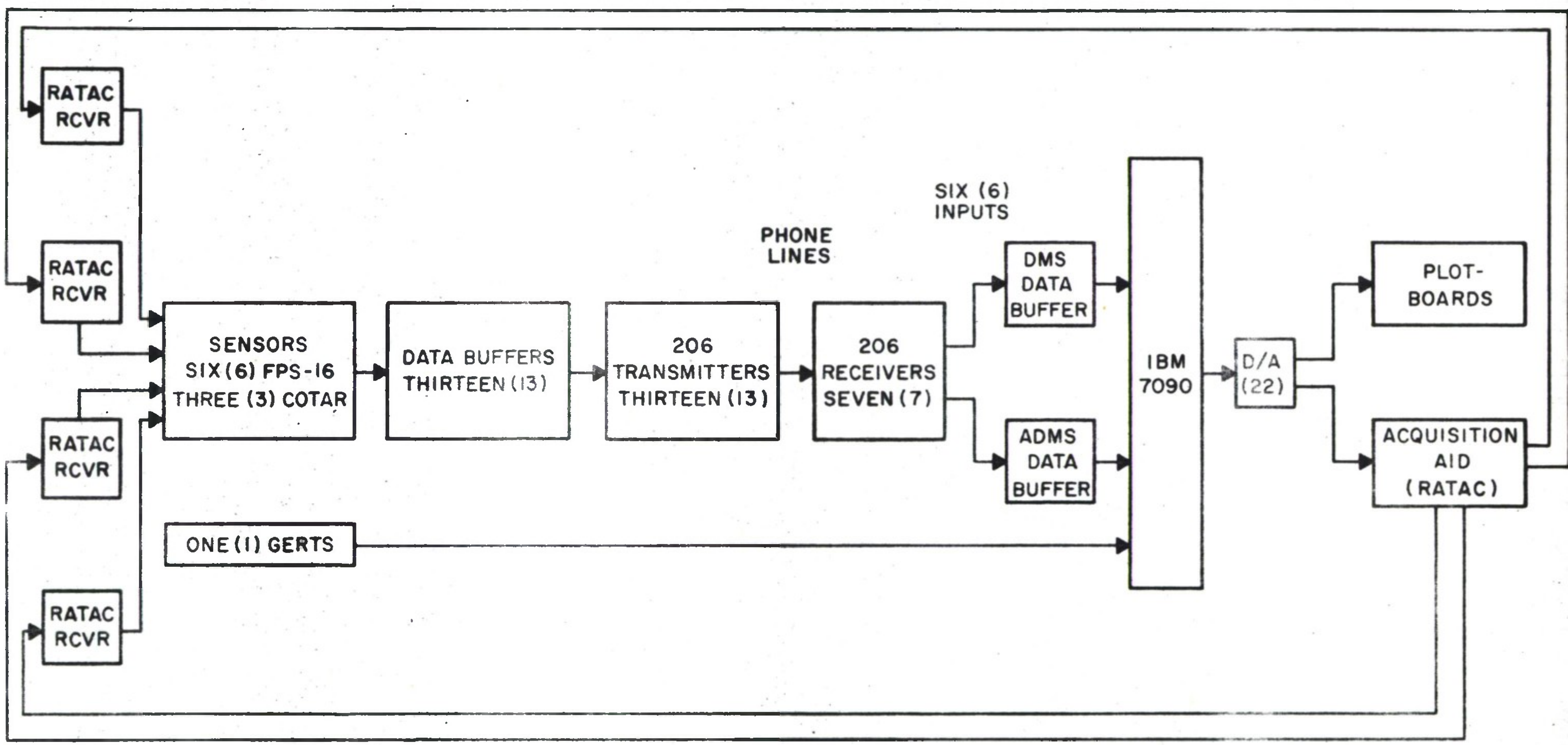
Eleven (11) 729-II magnetic tape units.

One (1) 7281 Real Time data communication channel.

One (1) IBM 1401 processor with 4000 character storage.

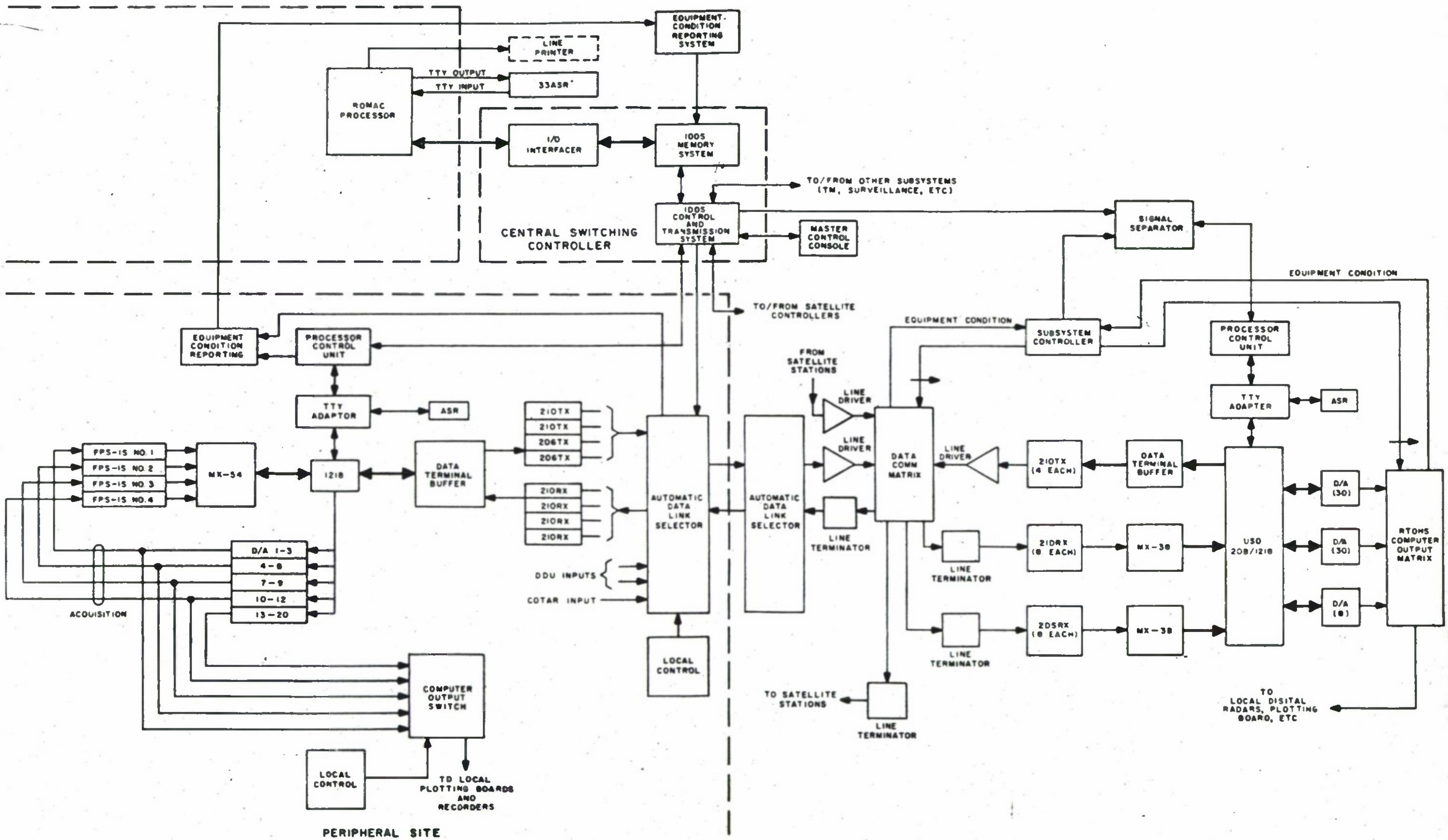
2.2 The existing IBM 7090/1401 data processing complex is discussed in Section 5 and listed in Appendix II.

2.3 A new system using the AN/USQ-20B computer, Figure 2, is presently being checked out. Present plans are to install a single AN/USQ-20B in this configuration. Dual sets of real time communications and interface equipment are being installed.



PRESENT POINT ARGUELLO RTDH SYSTEM

FIGURE 1



CONTRACTED POINT ARGUELLO RTDH SYSTEM

FIGURE 2

3. REQUIREMENTS FOR PRE-FLIGHT, REAL-TIME AND POST FLIGHT ANALYSIS

3.1 Discussion was held with the Navy regarding the data processing workload that they think is necessary to handle the present and future operational requirements of the PMR and for which they have been planning and implementing the RTDHS. These discussions and other analysis identified the total workload, which is now or may be, placed on the range data processing system during the 1965 to 1969 period.

Many of the following potential requirements which call for computer support are not embodied in firm program requirements at the present time. However, past range history and considerable documentation[1,2,3,4] support the likelihood of part or all of the requirements becoming formalized.

3.1.1 Salvo launch - the present single launches will increase to dual launches and may go to four vehicle salvos (for operational test).

3.1.2 Automatic abort capability, presently accomplished only for single launches, will be required for dual launches.

3.1.3 Data sampling rates - single launches presently require 10 sps - may go to 20 sps; dual launches - presently require 5 sps - may go to 10 sps.

3.1.4 Real time programs - may require improvement and expansion.

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1. Comparison of Central Data Processor for Range Safety at Point Arguello, TRU-108:168 Contract No. N123(61756) 23304A (PMR) Dec 21, 1962.
2. Information made available to ESD-NRD Computer Facility Analysis Group, 2 April 1964, Point Arguello.
3. OD for SAC MM Project "SALVO".
4. Appendix III.

3.1.5 Range operations monitoring and control functions within the real time system - may need to be extended.

3.1.6 Duplex real time system - may be needed for reliability.

3.1.7 Electronic displays - may be needed to improve data presentation.

3.1.8 Telemetry input to the real time system - may be a requirement for a quick look capability.

3.2 It should be noted that, for the foreseeable future, the major impact will come from the first three requirements as stated in paragraphs 3.1.1, 3.1.2, and 3.1.3.

Table 1 shows the types of tests that will incorporate these requirements in terms of their increasing demands on real time system performance. The first five types of tests are firmly required and specific in content; the next five types are not validated but may become firm during the considered time period.

TEST SUPPORT REQUIREMENTS

TABLE I

	Numbers of Simultaneous Launches	Automatic Abort Capability	Data Sampling Rate
Firm Requirements	Dual	None	5
	Dual	Single	5
	Dual	Dual	5
	Single	None	10
	Single	Single	10

TABLE 1 (CONTD)

	Numbers of Simultaneous Launches	Automatic Abort Capability	Data Sampling Rate
Possible Requirements	Dual	None	10
	Dual	Single	10
	Dual	Dual	10
	Single	None	20
	Single	Single	20

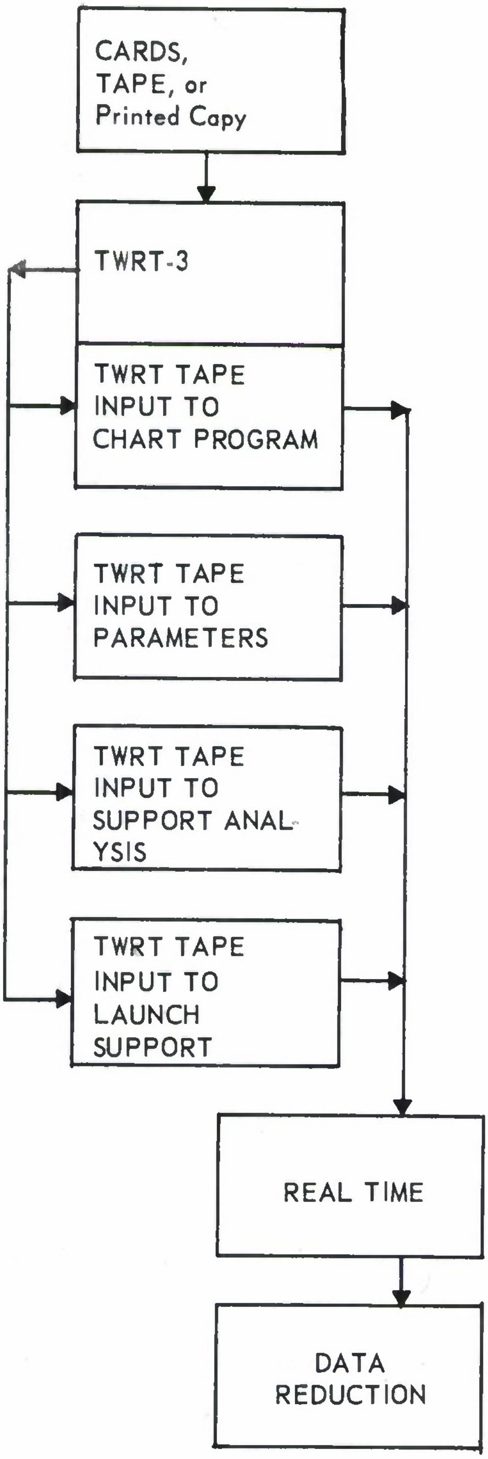
3.3 There are three major tasks to be assigned to the Real Time Range Safety Computation Center; (a) Pre-flight preparation, (b) Real-time control and recording, and (c) Post-flight data reduction and analysis. Experience firmly establishes that the computer capacity and speed which will satisfy (b) above will also satisfy (a) and (c). Therefore, it is necessary to identify computers which have adequate capacity and speed for (b). The machines which meet the speed and capacity requirements, need then to be checked to assure ability to handle the total workload (i.e., (a), (b) and (c) above) on a realistic basis (i.e., include time for maintenance, program improvement, inefficiencies of changing jobs on priority basis, etc.).

3.3.1 Pre-Flight Preparation

3.3.1.1 Figure 3 is a block diagram for range user data flow.[1] The elements of pre-flight preparation are the first six functional boxes which input to the "Real Time" function box of Figure 3. For the pre-flight phase, data is generated for producing range safety charts, parameters for the real time program, pre-launch support

1. Abstracted from briefing by Range Dept Personnel, U.S. Naval Missile Facility, Point Arguello.

RANGE USER DATA FLOW



Range user submits a data Package per COMPMR 5100.2C

Computer processes DATA PACKAGE OUTPUTS A STANDARD FORMAT "TWRT TAPE"

Many separate computer runs "As Required" Produce Data used by Draftsmen to draw RANGE SAFETY CHARTS (To be replaced by "Automatic Plotter)

Many separate computer runs "As Required" Produce Data used as PARAMETERS FOR REAL TIME PROGRAM.

Pre-Launch Support evaluation - Pre flight Simulations - Forcasting ANTENNA PATTERNS - etc.

Calculation of Dispersion Profiles, Launcher Settings, Acquisition Points, GERTS CUBES

Launch Support including About A 5 Hour count down and A 5 Minute Powered Flight

Analysis of Range Safety System and Computer Program Performance

FIGURE 3

evaluations and data for pre-launch support. At present, range safety charts are drawn manually from data which is computer generated. Sixty days notice is required for chart preparation. A curve tracer which will be computer driven is being procured to automate range safety chart production. The proposed Range Operations Monitoring and Control System (ROMAC) is not to be implemented (or if implemented would not be integral with the Air Force real time control system). If automatic monitor and control is implemented the Real Time computer system loading must be accounted for. Data was not available for this report that would allow estimation of the computer loading resulting from implementation of range operations monitoring and control functions via the real time system.

3.3.2 Real Time Control and Recording

3.3 2.1 The elements of the Real Time Control and Recording functions are discussed in Appendix III Report of the Computer Complex Coordination Committee, Subcommittee for RTDHS, PARSIP Requirements and Philosophy, dated 5 February 1964. This document discusses the anticipated sensor requirements. It accounts for, (a) dual salvo launches, (b) output data requirements as to type and quality, (c) real time control requirements, and (d) a refined and expanded real-time program set which would achieve better data quality and more precise missile control. The document does not discuss upgrading sensor performance, use of telemetry in real time, or use of electronic displays to augment or replace plotting board displays. Although a real time back-up system is implied, no justification for the use of a back-up system is given.

3.3.2.2 Three important firm operational requirements affect the computer speed and capacity requirements:

3.3.2.2.1 Salvos will consist of dual missile launches. However, due to the operational procedure of inputing the same number of sensors to the computer for single or dual launches (i.e., sensors are divided between launches), the computer is affected little by what missile the sensor is tracking. Based on this, single launches will require about the same computing capabilities as dual launches, exclusive of other factors.

3.3.2.2.2 Metric data sampling rates (from GERTS, FPS 16's and COTAR) may increase from 10 sps to 20 sps for single launches, and from 5 sps to 10 sps for dual launches.

3.3.2.2.3 Automatic abort capability is required for single and will be required for dual launches.

3.3.2.3 If future validation of requirements necessitates implementation of the recommendations given on pages 6-8 of Appendix III, the storage capacity and computation rate requirements will also increase. A quantitative estimate of the increase cannot be made from Appendix III since this document only defines types of possible improvements. With regard to storage capacity, the following are concluded: (a) Increase storage requirements due to dual launch computations and for increased sampling rates will not be significant, (b) Increased storage requirements to implement Appendix III may be significant but cannot be estimated on the basis of available data.

3.3.3 Post-Flight Data Reduction

3.3.3.1 Post-Flight data reduction is a service for the range users and range planners. For the former, tracking data serve as the source from which a mission information package is generated in 72 hours as well as a more detailed package which is generated in one to three weeks.

3.6.3.2 At present, all tracking data reduction is performed at Point Mugu. By July 1965, the Air Force facility at Point Arguello must be equipped to handle all ICBM and Space data reduction tasks.

4. DISCUSSION OF TECHNICAL SOLUTIONS

4.1 This section describes the capabilities of the existing computer system, discusses the data handling system which will meet the requirements for the next period (i.e., through FY-67 and possibly beyond depending on which future requirements are formalized and how soon they are formalized) and which can be operational by July 1 1965. This section also comments on required capabilities for the period beyond FY-67.

It is not deemed advisable to attempt to prescribe a system which will meet some of the requirements which are now only postulated for post FY-67, as such might well jeopardize meeting the July 1, 1965 operational due date.

In all cases a combined pre-flight preparation, real time, and post-flight data reduction facility is justified since the computing capacity and speed for the real time function will be more than adequate for the data reduction loading. The real time computer loading will account for only a portion of the available computer time.

4.2 The existing system is described in Section 2. The present real time program requires approximately 22,000 words of storage and 90 milliseconds of the allowed 100 millisecond sampling period (i.e., 10 sps) for single launch with automatic abort capabilities. Without automatic abort capability, approximately 80 milliseconds of the allowed 100 millisecond sampling period would be required.[1,2]

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[1] Comparison of Central Data Processor for Range Safety at Point Arguello, TRU-108:168 Contract No. N123(61756) 23304A (PMR), Dec 21 1962.

[2] Information made available to ESD-NRD Computer Facility Analysis Group, Telegram, June 20, 1964, Lt Col D. Coleman.

4.3 Two data handling systems were considered during this study.

4.3.1 The first system is obtained by modifying the present IBM 7090 to an IBM 7094. The 7094 will include four data channels and appropriate peripheral equipment and offers the following features:

(a) It will meet requirements for computing speed and accuracy through 1967 and marginally meet certain requirements which are most likely to come shortly after 1967 (i.e , growth potential). These capabilities are shown in Table 2, an extension of Table 1.

(b) Loading of a 7094 for the total requirements of pre-flight preparation, real-time, and post-flight data reduction would be at less than its maximum capacity, as shown in Table 3. These values are derived from Appendix I (figure 4) which analyzes pre-flight and post-flight data reduction computer loading for a 7090. The minimum and maximum values apply to the months when the ranges have the fewest or greatest number of firings respectively. The conclusion which is evident is that a 7094 working three (3) shifts per day, five days per week will handle the maximum data processing load with sufficient reserve time to allow for the inherent inefficiencies which may result from using the same facility for real time and non-real time functions If there should be overload, due to launch activity in excess of that estimated or due to excessive computer down time, such overload might be handled by the other 7090 type computers in the area, particularly the compatible 7094 at Point Mugu.

SOLUTIONS TO TEST REQUIREMENTS

TABLE 2

	REQUIREMENTS CRITERIA				SOLUTION					
	No. of Simulator Launches	Auto Abort	Data Sampling Rate (SPS)	Allowable Data Samp. Period (i.e.,1/SPS)	Computation Time for Data Sample: 7090	7094	7094II	USQ-20B: One (1)	Two (2)	Min Acceptable Computer
Firm Requirements	Dual	None	5	200	80			106		7090 or one 20B
	Dual	Single	5	200	90			120		7090 or one 20B
	Dual	Dual	5	200	100			133		7090 or one 20B
	Single	None	10	100	80			106	*58	7090 or two 20B's
	Single	Single	10	100	90			120	*70	7090 or two 20B's
Possible Requirements	Dual	None	10	100	80			106	**58	7090 or two 20B's
	Dual	Single	10	100	90			120	**70	7090 or two 20B's
	Dual	Dual	10	100	100			133	**74	7090 or two 20B's
	Single	None	20	50	80	47		106	*58	7094
	Single	Single	20	50	90	53	45	120	*70	7094 (Marginal) or 7094 II

↑ Units above line meet requirements
*Assumes 90% efficiency in splitting single launch between two computers
** One (1) USQ-20B used for each launch

	CAPACITY UTILIZED (SHIFTS)	
	7090	7094
PRE-FLIGHT PREPARATION	1/2 TO 1	1/3 TO 3/4
REAL TIME	1	3/4
POST-FLIGHT DATA REDUCTION	1/3 TO 1	1/4 TO 3/4
TOTAL	1 5/6 TO 3	1 1/4 TO 2 1/4

LOADING OF PROPOSED 7094 SYSTEM

TABLE 3

(c) The 7094 can be obtained by a field modification of the present IBM 7090 and contracted on a rental basis at only a 15% increase in cost over present equipment. This allows freedom to change as the post 1967 requirements firm up and the Air Force gains more experience with the WTR

(d) Reprogramming would be minimal.

(e) Application support and experience is known to be extensive

(f) Reliability is proven to be excellent, (Appendix IV).

4.3.2 The other system considered is multiple AN/USQ-20B's which the Navy has procured and is installing It has been agreed that the Air Force can assume these units or not as desired. Analysis included the following about the AN/USQ-20B system:

(a) The present pre-flight preparation and post-flight data reduction programs for the 7090 type computers represent 275 man-years of programming effort. Presumably, these programs will be available to the Air Force. Conversion of these programs from 7094 language to AN/USQ-20B language is expensive of time and manpower.

(b) Other 7094 computers in the area (Point Mugu and Others) could not be used for overload.

(c) In the re-evaluations of system capability to support the future requirements, if a change were warranted, the fact that the AN/USQ-20B is a government purchased machine would tend to influence a decision toward modification or augmentation of the present equipment, rather than go to a system or machine that would completely satisfy the new needs.

(d) Application support and experience in its use is limited.

(e) For a representative computer program the AN/USQ-20B has a computing speed which is 75% that of the 7090 and 45% that of the 7094. Comparing this in Table 2, shows that two AN/USQ-20B computers are required for known requirements.

4.4 Capabilities for potential computer requirements beyond 1967 are yet to be formalized. Though the IBM 7094 system will not meet all of these requirements, it should be seen in Table 2 that most of the more likely requirements beyond 1967 can be met. Table 2 shows that the requirement which does exceed the capacity of the 7094 can be met within the capabilities of the 7094II. However, if various improvements in the real time programs suggested in Appendix II are implemented and/or the sampling rate increases for dual launches to 20SPS, the 7094II would not be adequate. This suggests the need for a major change if enough of the proposed requirements of section 3.1 become firm.

5. COST OF DATA PROCESSING SYSTEMS

5.1 A Data Processing System includes the central processing unit and those units of peripheral equipment determined necessary to handle the tasks assigned. A System Facility is defined as two or more central processors together with the units of peripheral equipment necessary to handle the tasks assigned.

5.2 The presently installed data processing equipment is listed in total in Appendix IV. The prime shift monthly rental cost of each unit and the total monthly cost are included.

5.3 Also listed is the prime shift cost of the 7094/1401, 7094II/1401 equipment identified in Sections 4 and 6.

5.4 Below is a comparison of the composite monthly prime shift costs of each facility:

Complex	7090/1401	7094/1401	7094II/1401
Monthly Cost	$74, 830	$99, 375	$104, 405

5.5 Discussion of the suitability of the AN/USQ-20B System is contained in paragraph 4. 3. 2. Recommendations as to continuing the use of this system are contained in paragraphs 6. 3. Based upon the negative recommendation and the reasons leading to the recommendation, it is unnecessary to itemize the AN/USQ-20B system unit cost in this section.

5.6 The dual printer configuration and/or the ability to share the disk file may not be available in the IBM 1401 computer. It is available in the 1460 computer. Therefore, the IBM 1460 complex is also costed. It will be noted that the increase is approximately 1% above the total system cost shown above.

5.7 Conclusions of the foregoing sections determine that the recommended equipment will be sufficient at least until 1967 and possibly until 1969. However, it is appropriate to consider a short term renewable rental contract with a non-penalty clause for termination.

6. RECOMMENDATIONS

6.1 It is recommended that the present IBM 7090 Data Processing System be upgraded to an IBM 7094 system. It will include four data channels and appropriate peripheral equipment such that it will be compatible with the Point Mugu IBM 7094 data reduction facility. This improvement, including system and program checkout, must be accomplished in sufficient time so that the Point Arguello facility will be operational prior to 1 July 1965. These recommendations are based upon the following:

6.1.1 AFWTR will accept entire operational programming responsibility for computer support of the WTR operation as of 1 July 1965.

6.1.2 With practical usage considered, including conflicts between real time and non-real time use of the facility and maintenance time, the 7094 will fulfill requirements on a three shift operation. If data reduction overruns are experienced, they may be accomodated on the compatible Pt. Mugu IBM 7094 system.

6.1.3 A minimum of confusion will be introduced during a difficult transition period. This is due to:

6.1.3.1 Minimizing of programming effort (only verification of Point Mugu Programs will be necessary).

6 1.3.2 Training of personnel on new equipment is minimized.

6.1.3.3 Modification of facilities is minimized.

6.1.4 The high reliability of the 7094 precludes the need for a real-time back-up system for reliability.

6.2 It is recommended that the appropriate Navy pre-flight and post-flight data reduction programs be acquired for use at the Air Force facility.

6.2.1 A compatibility of systems will allow one set of programs to be used at both locations.

6.2.2 To accomplish the present data reduction at Point Mugu on an IBM 7094 requires 369 post-flight data reduction programs. The development effort of these programs represents approximately 275 man-years. The time available makes it impractical to attempt reprogramming for some other machine.

6.3 It is recommended that the installation of the AN/USQ-20B computer be discontinued due to (a) extensive programming cost and time; (b) lack of compatibility with other computers for overload support; (c) limited application support and experience in use; and (d) due to the firm future commitment inferred by purchase rather than rental.

6.4 The recommendations in paragraph 6.1, 6.2, and 6.3 are based upon the specified needs for the period FY-65 through FY-69. These needs were identified during the quick analysis of the forecasted range loading. Because of the trend toward increased requirements, as stated in Section 3, it is recommended that a re-appraisal of the computer system loading beyond FY-67 be accomplished in late FY-65 or early FY-66.

APPENDIX I

1. REQUIREMENTS FOR PRE-FLIGHT, REAL-TIME AND POST-FLIGHT ANALYSIS

The purpose of this analysis is to determine the amount of computer capacity required to accomplish both real time and non-real time data reduction at Pt Arguello during the period FY-65 through FY-69. Since the existing computer at Pt Arguello is an IBM 7090 and statistical data is available on its use, this analysis expresses the forecasted workload in terms of 7090 computer hours.

Figure 4 represents, in graph form, the forecasted computer workload at Pt Arguello through the period FY-69. An explanation of the functional categories listed in the lefthand column is given below.

1.1 Computer Hours

1.1.1 Average Real Time 7090 Computer Hours: This represents computer time accrued during the period when real time data sources are connected to the computer input. Each launch requires approximately five hours of computer time; however, due to "holds" and other factors, experience has shown that there are, on the average, approximately 1.9 countdowns per launch. Therefore, the average computer time per missile is 9.5 hours.

1.1.2 Pre-Flight Preparation, 7090 Computer Hours;
Hours in this category represent computer time to support the real-time operation, plus some time which could be considered as preparation for post-flight data reduction; i.e., system tape check-out, code checking, pre-and post-flight calculations, destruct criteria for range safety charts, simulation, reduction for Range Safety reports, and analysis. Twenty percent (20%) of the pre-flight preparation is utilized for program checkout and house-keeping functions.

1.1.3 Average Post-Flight 7090 Computer Hours: These hours represent the total ICBM and Space Vehicle computer time which is equivalent to work now done on the Pt Mugu 7094 computer. Specific work includes such things as program development, and also analysis and data reduction for the post-flight test reports, etc.

1.1.4 Total 7090 Computer Hours: This is the grand total for the three categories covered above in subparagraph 1.1.1, 1.1.2, and 1.1.3.

1.1.5 70% of 7090 Total Computer Hours: Based on past experience, approximately 70% of the scheduled launches will materialize. This experience factor results from scheduled re-runs of actual launches on the PMR during past years. This fact has also been proven for AMR experience. Consequently, the actual forecast of total 7090 computer hours is reduced by approximately 30%.

1.2 Computer Workload:

Figure 4 is a plot of computer workload in terms of 7090 computer hours versus fiscal year. An explanation of this plot is given below.

1.2.1 Area A represents the time that the computer is not available for use due to preventive and corrective maintenance. The 182 hours per quarter is based on 2 hours per day for 91 days per quarter.

1.2.2 Area B represents the real time workload in terms of 7090 computer hours based on 70% of scheduled launches.

1.2.3 Area C represents the workload in terms of 7090 computer hours for both real time support and post-flight data reduction. Hours are based on 70% of scheduled launches.

1.2.4 Area D represents an additional workload that could result if 100% of scheduled missiles are launched.

1.2.5 The dashed line labeled 2184 hours represents the maximum availability of the computer for any purpose. The 2184 hours is based on 24 hours per day availability for 91 days per quarter.

1.3 CONCLUSIONS:

The following conclusions can be drawn from the plot shown in Figure 4::

1.3.1 For a rate of 70% of scheduled launches, the 7090 computer can handle the real time computer workload on an average of one shift per day for a five day work week.

1.3.2 The non-real time data reduction represents a large portion of the total workload. Even if 70% of scheduled missiles were launched and the same computer is used for both real time and non-real time work, at least a two-shift operation would be mandatory seven days a week.

1.3.3 If 100% of the scheduled missiles were launched, a 3-shift operation seven days a week would be needed.

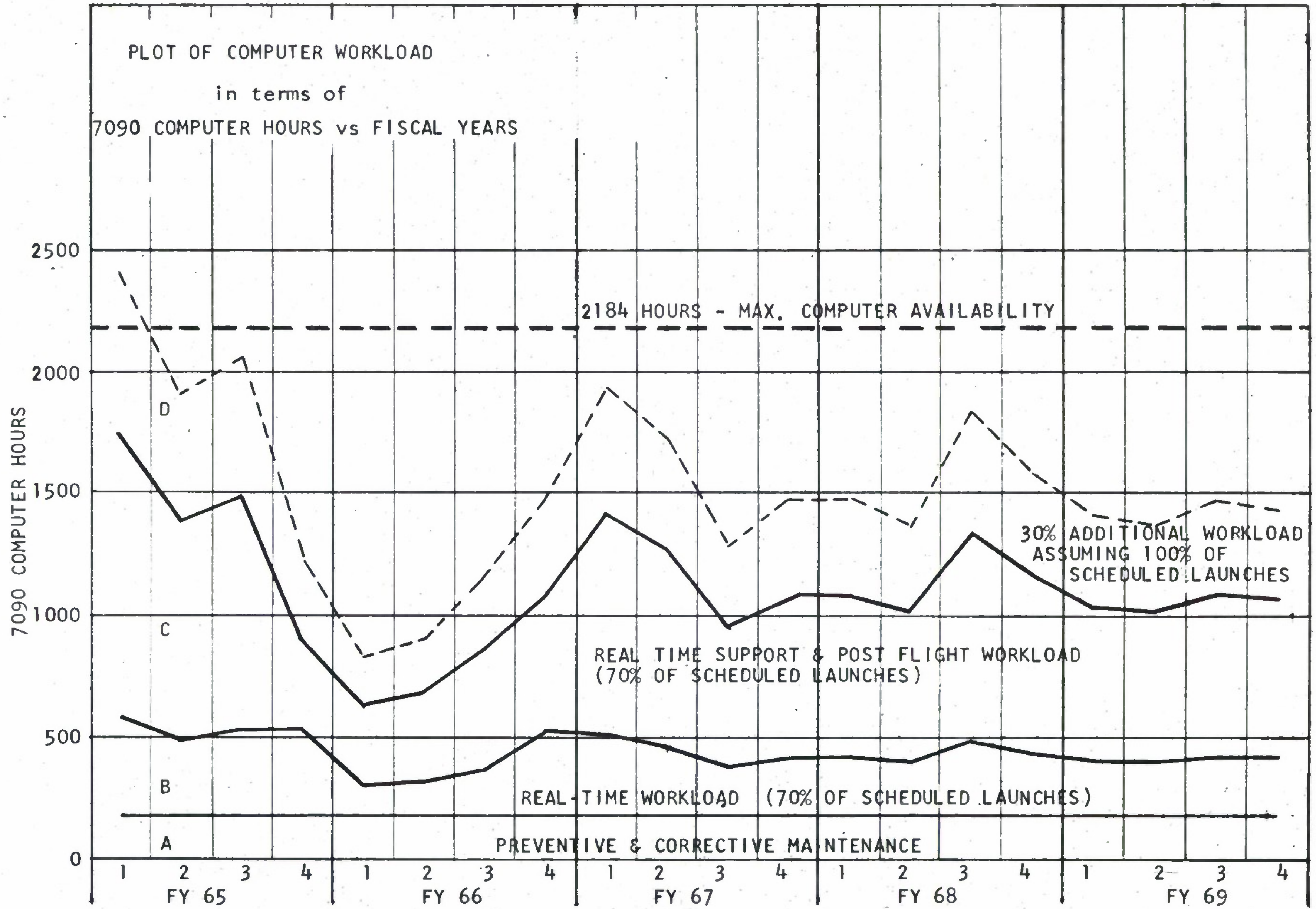
PLOT OF COMPUTER WORKLOAD
in terms of
7090 COMPUTER HOURS vs FISCAL YEARS
7090 COMPUTER HOURS
2500
2000
1500
1000
500
0
2184 HOURS - MAX. COMPUTER AVAILABILITY
D
C
B
A
30% ADDITIONAL WORKLOAD ASSUMING 100% OF SCHEDULED LAUNCHES
REAL TIME SUPPORT & POST FLIGHT WORKLOAD (70% OF SCHEDULED LAUNCHES)
REAL-TIME WORKLOAD (70% OF SCHEDULED LAUNCHES)
PREVENTIVE & CORRECTIVE MAINTENANCE
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
FY 65
FY 66
FY 67
FY 68
FY 69

FIGURE 4

APPENDIX II

This listing is those units considered necessary to complete the Data Processing Facility as described in the report. All costs are primary shift costs. Additional shifts would entail a 40% increase to the list cost.

Point Arguello Data Processing Complex

UNIT		COST (DOLLARS)		
GROUP A		7090	7094	7094II
Processing Unit	7108/7110/7111	10, 660	16, 635	20, 260
Arithmetic Sequence Unit	7109	8, 825	8, 925	8, 825
Card Reader	711	800	800	800
Printer	716	1, 275	1, 275	1, 275
Console Control Unit	7151	1, 225	1, 450	1, 425
Remote Control Unit	7155	55	55	55
Real Time Data Communication Channel	7281	7, 585	7, 585	7, 585
Core Storage	7302	17, 500	17, 500	19, 000
Multiplexer	7606	4, 270	4, 320	4, 970
Mag Tape (5)	729II	3, 500	-	-
Mag Tape (9)	729VI	-	8, 550	8, 550
Mag Tape (2) (Switchable)	729II	1, 570	-	-

UNIT		COST (DOLLARS)		
Group A		7090	7094	7094II
Mag Tape (2)	729II (switchable)		2,070	2,070
Data Channel Mod 1	7606	4,275	4,360	4,360
Data Channel Mod 2	7606	3,980	3,360	
Data Channel ——	7606	-	4,230	4,230
Power Converter	7608	700	700	700
Data Channel (2)	7617	450	450	450
Data Channel (1)	7617 (additional)	-	225	225
Power Control	7618	900	900	900
Disk Storage Model 1	1301		2,100	2,100
File Control Model 2	7631		860	860
Data Channel Model 1	7909		2,800	2,800
Group A Sub Total		$66,865.	$89,770	$94,800
Group A & B Total		74,830.	99,375	104,405
Group A & C Total		N/A	100,580	105,610

Group B		1401	Dual Channel 1401	Dual Channel 1401
Central Processing Unit	1401	3, 660	3, 725	3, 725
Card Read Punch	1402	560	560	560
Printer	1403	775	2 ,350	2, 350
Magnetic Tape (2)	729II	1, 400	1, 400	1, 400
Magnetic Tape Switchable (2)	729	1, 570	1, 570	1, 570
Group B Sub Total		$7, 965	$ 9, 605	$9, 605
Group A & B Total		$74, 830	$99, 375	$104, 405

Group C		1460	1460
Central Processing Unit	1441	2, 130	2, 130
In-Out Control Mod 2	1461	1, 980	1, 980
Console, With Switch	1447	95	95
Card Reader	1402	560	560
Printer (2)	1403	1, 575	1, 575
Printer Storage	#5585	375	375
Printer Control Adapter - 2nd Pringer	#5580	105	105
Printer Control Unit	1462	1, 020	1, 020
Magnetic Tape Switchable (2)	729	1, 570	1, 570
Magnetic Tape (2)	729II	1, 400	1, 400
Group C Subtotal		10, 810	10, 810
Group A & C Total		100, 580	105, 610

APPENDIX III

REPORT OF THE COMPUTER COMPLEX COORDINATION COMMITTEE SUBCOMMITTEE FOR RTDHS PARSIP REQUIREMENTS AND PHILOSOPHY

Ref: (a) PMR Real Time Data Handling System, System Description and Programming Concept by Informatics, Inc.

1. This committee concerned itself only with the RTDHS primary site at NMFPA and did not consider the capabilities that will exist and could be used at the peripheral sites or at the Point Mugu primary site. The committee used as a basis for its discussions the RTDHS primary site configuration for NMFPA described in reference (a). This report summarizes the committee's conclusions and recommendations on the following subjects related to the RTDHS PARSIP.

   a. Input requirements

   b. Output requirements

   c. Implementation plan

This report concerns only the real time capability required to provide range support for satellite and ICBM launches from the NMFPA/VAFB complex in the next two to three years. It is primarily aimed at range safety requirements but an attempt was made to generalize the capability so that other real time requirements would also be met. Justifications or background related to the recommendations made herein are not presented in the interest of brevity.

2. The heaviest input/output requirements are expected to arise from salvo launches. It is expected that for the period of interest no more than 4 missiles would be launched in salvo. A minimum of two radars or sensors per missile will be required and will be providing input data. This means a minimum of 8 sensors would be providing input while the RTDHS will have a system capability of receiving data from as many as 16 input sensors. The total number of sensor systems capable of providing digitized inputs will be 15. These will include COTAR, GERTS, FPS-16, and all weather radar data. Of the 4 missiles launched in salvo, there will be a range safety requirement for computer or automatic abort for no more than two of the missiles.

In order to provide the best output data, the sampling rate of the input data should be as high as possible. The sampling rate need not necessarily be the same for all sensors. Depending on output requirements of the specific operation the sampling rate could be varied in order to maintain the system operating at near peak capacity on all operations. For example, the output requirements for a salvo operation may be such that the sampling rate is limited to 10 sps by the computer capability but for an operation having only one launch the sampling rate could be increased to 20 sps. Further, the sampling rate may be varied as the sensor requirement or computer capability varies during an operation.

3. The minimum <u>real time</u> output requirements will be:

a. Tangent plane present position (X, Y, Z).

b. Tangent plane velocity versus time(V).

c. Present position range (R).

d. IIP latitude and longitude.

e. Theta versus time (Θ).

In the case of salvo operations these quantities will be required for each missile. The same output quantity may be required at more than one scale. While not an actual output in the display sense, the system will also be required to make abort decisions internally and initiate appropriate abort functions. A so called "history tape" output will also be required. All inputs to the primary computer, including sensor data and control switch settings, should be recorded such that an accurate and realistic simulation can be made of the operation after it has occurred. Results of intermediate and final calculations made in the computer should also be recorded as required.

The output quantities should be of the highest possible quality. In attaining this quality, the following techniques should be studies and used when practical:

a. Variable data sampling rate.

b. Refraction corrections to raw radar data.

c. An N station or composite solution based on a real time volume of error analysis.

d. Automatic internal selection of the best sensor data.

e. Smoothing and editing of raw and calculated data.

f. Exponential or other type filters which will give a smooth real-time velocity.

g. Atmospheric drag and earth's oblateness corrections made to the IIP.

The IIP calculations should be continually improved until the system eventually provides impact points or a debris pattern for multiple objects. This IIP capability should be available for the entire flight rather than just the terminal portion. The IIP should also be corrected for a wind profile in both the launch area and the target area.

A higher developed automatic abort capability compatible with both GERTS and FPS-16 data will be necessary. The automatic abort capability should provide for multiple abort lines, N-sided uncertainty boxes, and multiple uncertainty box sets. As mentioned above, the system should be capable of handling a salvo of 4 missiles, two of which would require automatic abort calculations. In this case the work load would probably be divided equally between primary computers by supporting one manual and one automatic abort mission with each computer. The program should also have provisions for making a "time to fly" calculation in the event that all sensor data is lost. The ultimate system required during the period of consideration may also include instantaneous orbit determination calculations which would be used in either manual or automatic abort criteria. It may also be necessary to monitor, reduce and utilize telemetry data in making range safety decisions.

4. The RTDHS PARSIP philosophy should generally follow the programming and range safety philosophy followed in the past and incorporated in the present PARSIP. All quantities that could be considered a variable in any way should be specified as an input parameter. This philosophy is followed in order to guarantee maximum flexibility and a long program lifetime. The philosophy of maintaining only one operational RTDHS PARSIP or system tape should be followed. If the program becomes too large with respect to the system storage capability or if other significant factors become evident an alternate philosophy could be followed. In this case, a single complete PARSIP would be maintained, but a system tape would be generated for each individual operation. This system tape would be generated by calling from the master PARSIP only the routines required to support the specific requirements of an individual operation. This system tape would also contain the required input parameters for the

operation and it would be checked out in the usual manner by simulations. The system tape for an operation would be retained and filed in a manner similar to that presently followed for parameter tapes.

Whenever decisions such as automatic data selection, composite solution, or abort determination are made internally by program logic, a manual override capability must be present. The quality of the automatic abort capability must be such that missiles are not aborted unless they have violated predefined range safety criteria and missiles which have violated this criteria will be aborted with a high probability. Where possible, the system should be programmed such that if a single computer fails, a limited capability would remain as a result of a so-called graceful degradation of the system. When possible, the primary computer should monitor, report, and in some cases act upon current system configuration, status, and capabilities.

5. It is recommended that the programming and implementation of the RTDHS PARSIP be approached on a step by step basis. Each step could be defined by a distinct phase and generally major work on each successive phase would not begin until the preceeding phase was completed and in operation. However, before work begins, specifications should be established for the program resulting from the completion of each

phase. This approach would provide an early operational capability and experience gained in the development of the earlier phases could be used beneficially in development of successive phases. This plan would also make the most effective use of the limited manpower resources for this task.

Documentation is always an important part of the development of a system and it is especially important in the development of the RTDHS PARSIP. Documentation plans, specifications and procedures should be established in the very early development stages. These procedures should then be rigidly enforced during the development of the system. The suggestions made in Section 7. 4 and Appendix C of reference(a) are recommended as a framework around which the documentation procedures can be laid out.

The development of the ultimate system capability has been broken into five phases as outlined below:

a. Phase I would be limited to

    1) FPS-16 radar and COTAR input sources

    2) Variable data sampling rates

    3) Automatic selection of best sensor data

    4) Data smoothing and editing and use of exponential filters or their equivalent

5) Real time present position and velocity outputs

6) A real time IIP computed on a spherical, rotating earth in the absence of an atmosphere

b. In Phase II, the system would be expanded to include

1) Refraction corrections to individual sensor data

2) A real time volume of error analysis and composite solution

3) Drag (no wind) and oblateness correction applied to the IIP during terminal portion of flight

4) An initial salvo support capability (limited to two missiles with manual abort capability only)

5) Computation of acquisition data for remote radar sites

c. In Phase III, the system would be expanded to include

1) Provision for GERTS track and rate input data

d. In Phase IV, the system would be expanded to include

1) Automatic abort capability utilizing multiple short lines, N-sided uncertainty boxes, and multiple uncertainty box sets

2) "Time to fly" calculation in the event of loss of all sensor inputs

3) An ultimate salvo support capability (capable of supporting a salvo of 4 missiles, 2 of which would require automatic abort calculations)

e. In Phase V, the system would be expanded to include

1) A drag corrected IIP for the entire flight. Inpact points for multiple objects and/or debris patterns would be calculated. Corrections would be made for the effects of measured wind profiles in the launch and target areas.

2) An instantaneous orbit determination calculation

3) A capability to monitor, reduce and utilize a variety of real time telemetry data

It is estimated that these phases could be completed in a timely manner by 4-6 experienced and capable mathematican/programmers working on each phase serially. (Same persons assigned to the task from Phase I through Phase V.) It is expected that the following level of effort will be required.

a. Phase I	3 manyears
b. Phase II	2 manyears
c. Phase III	1 1/2 manyears
d. Phase IV	3 1/2 manyears
e. Phase V	Open, pending definite specification and requirements

This report is submitted by Carl Gerbert.

/s/ Carl Gerbert
CARL GERBERT

Committee members

Carl Gerbert, Chairman — Range Safety

G. Cragun	3285
R. L. Patton	FEC
F. Roscoe	FEC
LCDR Ziebell	7140

APPENDIX IV

C O P Y

7140/km
852
10 Apr 1964

From: Commanding Officer, U. S. Naval Missile Facility Point Arguello, Lompoc, California

To: Commander, Air Force Space Test Center, Vandenberg Air Force Base, California

Subj: IBM 7090 Computer System; reliability of

Ref: (a) Telcon LCOL D. M. COLEMAN (AFSTC) and CDR W. A. SCHWEN (NMFPA) of 10 Apr 1964

1. The following information is submitted in response of reference (a).

2. The Point Arguello 7090 Computer System has been used in support of Range Safety since September 1961, and has proven itself to be the most reliable portion of the Range Safety System. There has never been a hardware failure during the flight phase of an operation, and only two range holds attributed to the 7090 System. A 90-minute hold occurred on 24 February 1964, because of a lost "sign" bit, due to a faulty circuit card in the 7109. A 90-second hold occurred on 12 March 1963, because of a loose wire in the 7281, subsequent to personnel working inside the unit.

3. Experience with the 7090 System has shown that most failures occur during the first hour of operation after the application of electrical power, and that most potential problems are detected and corrected during scheduled diagnostic runs by IBM maintenance personnel. During the past year 14 non-scheduled maintenance periods were required, with a total of 48 hours down time. Five of these periods closely followed unscheduled electrical power interruptions.

/s/ W. T. Bruck

W. T. BRUCK
By direction

D. H. ZIEBELL/Ext. 381
10 Apr 64

C O P Y